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ON THE ORIGIN AND DISTRIBUTION OF THUNDERSTORM ELECTRICITY

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Experiment shows that when an uncharged drop of approximately pure water, such as rain water, is broken up by a jet of air, the spray particles so produced are negatively charged and the remaining larger portion of the drop positively charged. We also know from experiment that water drops cannot fall through still air of normal density at a greater velocity than about 26 feet per second, nor fall at all through, but rather rise with, air that has a greater-than-this velocity of ascent, since drops large enough to acquire a higher velocity, if solid, are so agitated by the swiftly passing air that they break into smaller drops that are then carried up. We further know, by inference from the occurrence of large hailstones, and directly from the experience of aviators, that within thunderstorm clouds there commonly are currents of air with such velocity of ascent that rain cannot fall through them, and within which all especially large drops, formed by coalescence or otherwise, are promptly ruptured and their parts dispersed—the smaller carried off from the larger.

These facts constitute the logically coherent basis of C. G. Simpson's well-known rupture theory of the origin of thunderstorm electricity, or electrification of the cumulo-nimbus cloud whose abrupt discharge is lightning. Naturally it was inferred that of the electricity obtained in this way the negative portion, being on or associated with, the smaller droplets, must be chiefly at or near the top of the cloud, and the positive, being on the larger drops, near its base. Numerous observations, however, have shown that in general, but not always, the distribution of the electricity is just the reverse of this, that is, the upper portion of the cloud is, on the whole, positively charged and the lower portion negatively charged. This observed distribution of the electricity is so definitely opposite to that which has seemed all but inevitable on the rupture theory that many have felt compelled to reject that theory entirely, even when they knew of none other that to them was more acceptable.

But is the inference that on the rupture theory the upper portion of the cloud must be negative and the lower positive correct? Evidently the latent heat of condensation of the condensing vapor keeps the air within the rising cloud slightly warmer and therefore lighter than the outer air, level for level, otherwise there would be no ascent of the air within this cloud—nothing of the local chimney effect it displays. Clearly, too, the velocity of ascent of each small portion of the rising air must increase until the weight of the liquid water entrained by it and the friction between it and the adjacent air are together equal to its buoyancy. The mean level at which this condition occurs, or mean level of maximum velocity of ascent of the rising air within a thunderstorm cloud appears, according to the experience of aviators, to be well above the halfway point between its base and its top. Furthermore, since this velocity commonly is so great that raindrops cannot fall through the air at its level, it follows that the greatest concentration of large drops, and therefore the seat of the most active electric separation must be at a still higher level—the level at which drops can just maintain their position against the ascending air. This level, as previously explained, seems commonly to be in the upper portion of the cloud; and if that is its normal location then most of the positive charge usually is well above the midheight of the cloud in which it is produced.

The negative electricity presumably is first carried to, or near to, the top of the cumulus and then from there pulled down along, or near to, the cloud wall by the well-known descending air that commonly flows down the sides of high cumulus clouds, incident to cooling of the containing air by evaporation at the cloud surface. A portion of this descending negative electricity may be caught up by the ascending air and partially neutralize any falling positive drops, another portion largely captured by the finer cloud droplets near the base of the cloud, and the rest, together with the second portion also, and all the positive charges, either neutralized within the cloud, as is the first portion, carried down on the rain, or violently ejected in the form of discharges. At any rate the known movements of the air in and about an active thunderstorm cloud may not only produce abundant electric separation, or electrification, through rupture of the larger (maximum size) raindrops but also so distribute the charges thus produced that more positive electricity will be above the midlevel of the cloud in which it was generated than below that level. If so, then the most serious objection that has been made to the Simpson rupture theory of the electrification of the cumulo-nimbus, or thunderstorm cloud, is not an objection at all, but a confirmation.

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